Management of apple scab beyond the models: Lessons learned from cultivar selection and off-season fungicide applications



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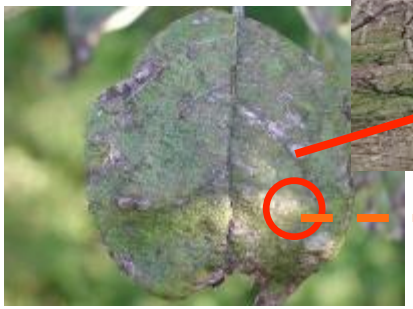
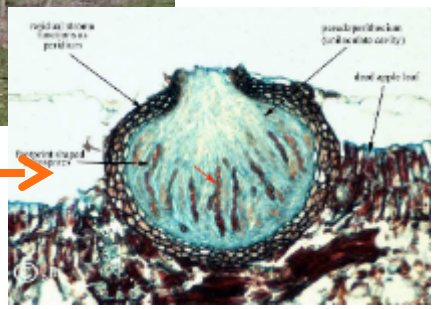
Apple Scab Management: Models + Fungicides

Dormant / silver: urea, copper + “cultural control”



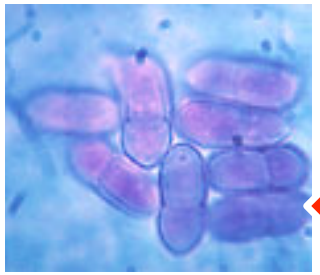





http://www.uoguelph.ca/~gbarron/Misc2009/applemic.htm

Green tip, ½ inch green, tight cluster: captozeb, dodine




Apple Scab Management: Models + Fungicides

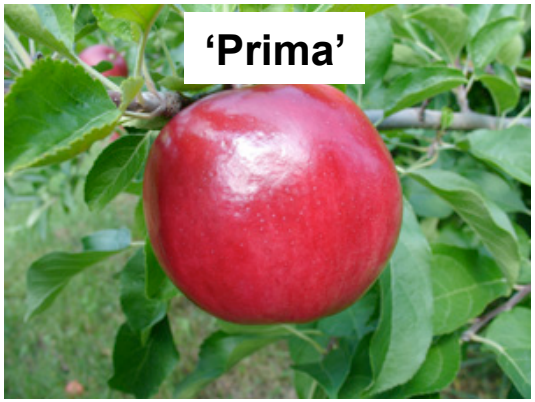
single-site fungicide + protectant




- Single-site fungicides
  - ~~Benzimidazoles~~, ~~guanidines (dodine)~~, **DMIs, QoIs, SDHIs**
  - \+ Manage number of phytopathogenic fungi
  - \+ Minimize harmful effects to non-targets and environment
  - \+ High level of protective and curative (?) activity
  - − Specificity fosters development of resistant populations with repetitive use

Apple Scab Management Options: Host Resistance

- Vf gene: single gene resistance (qualitative)
  - >40 scab resistant cultivars since 1970
    - "not one has been met with commercial success" Belfanti et al. 2003



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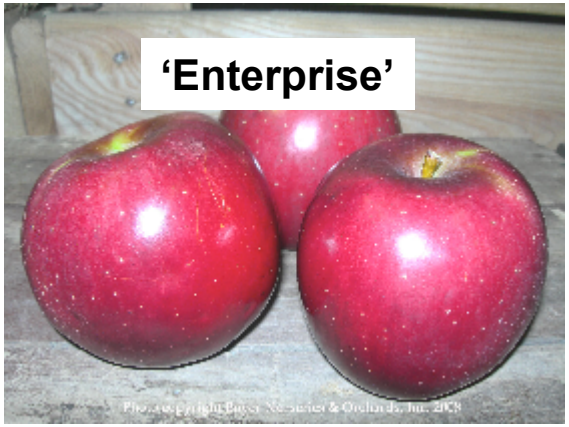

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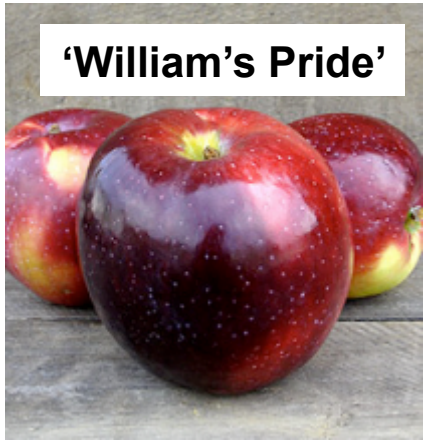
http://kuffelcreek.wordpress.com/

http://www.eatlikenoone.com/pristine-apples.htm



http://www.plant.photos.net/index.php?title=File:Apple_williams_pride.jpg

http://www.plant.photos.net/index.php?title=File:Apple_libertye.jpg

Apple Scab Management Options: Host Resistance

- Horizontal (quantitative) resistance
  - varying susceptibility to leaf and/or fruit scab

Cultivar	Resistance Level
Honey Crisp	moderately resistant
Fuji	susceptible
Golden Delicious	susceptible
Jonagold	susceptible
Granny Smith	susceptible
Cortland	very susceptible
Empire	very susceptible
Gala	very susceptible
Ginger Gold	very susceptible
McIntosh	very susceptible

Source: http://www.extension.purdue.edu/extmedia/BP/BP-132-W.pdf

Apple Scab Management Challenges

- Host resistance: Fruit quality/consumer preference, other diseases, pathogen adaptability
  - New cultivars: Many are highly susceptible
- Single-site Fungicides: Practical/field resistance
  - Single chemistry and multiple resistance
  - Impact on managing other diseases with same fungicides
- High inoculum levels/overwintering populations

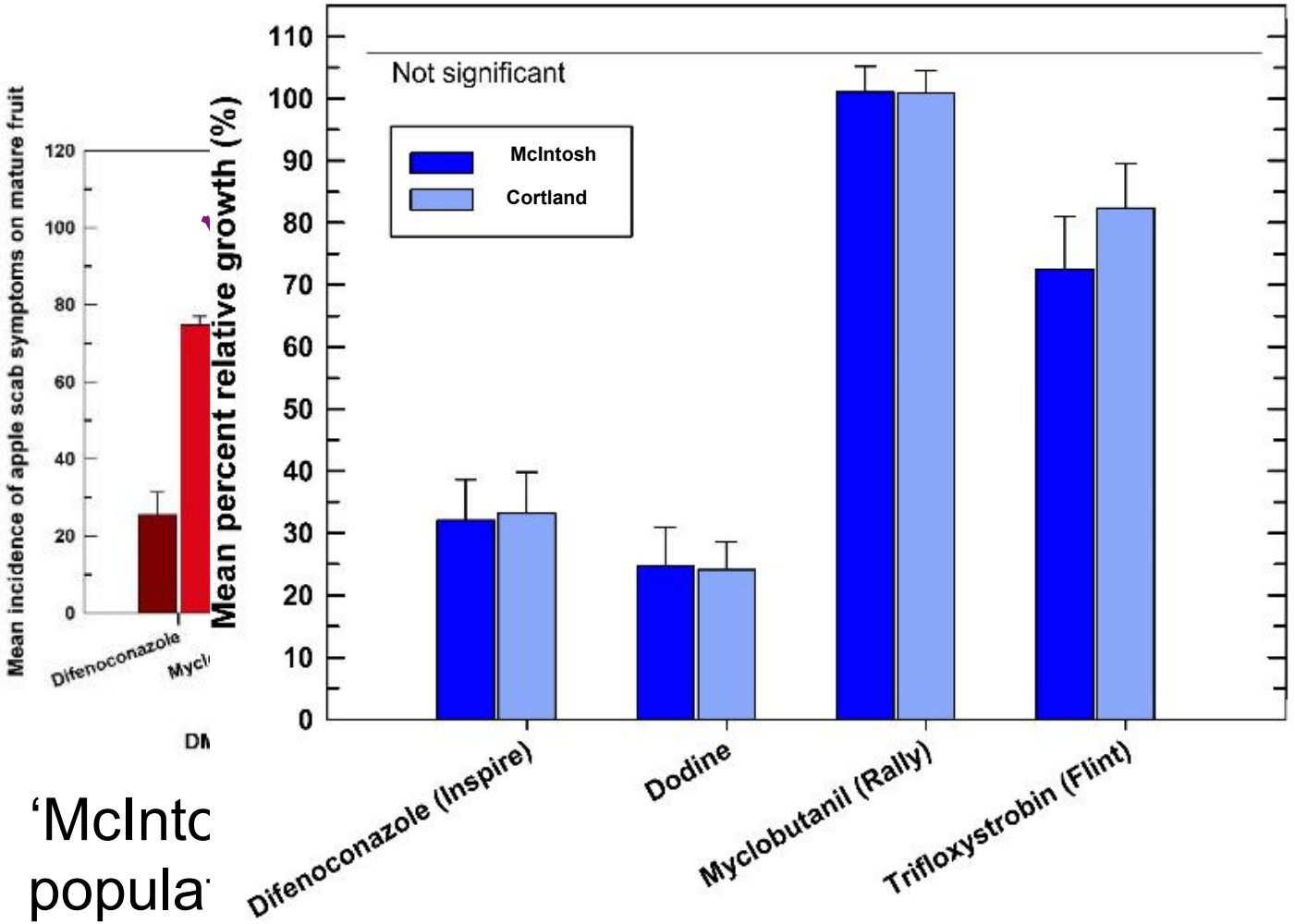
Apple Scab Management Challenges

How do we manage apple scab when it's increasingly becoming resistant to everything?

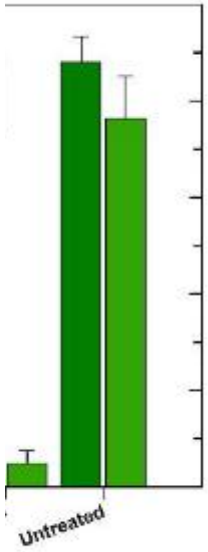
- Can minor differences in cultivar susceptibility mitigate the effects of practical fungicide resistance in populations of *Venturia inaequalis*?

- What are the implications of "off season" fungicide sprays on selecting for DMI resistance in populations of *V. inaequalis*?

Cultivar Contribution towards Practical Resistance

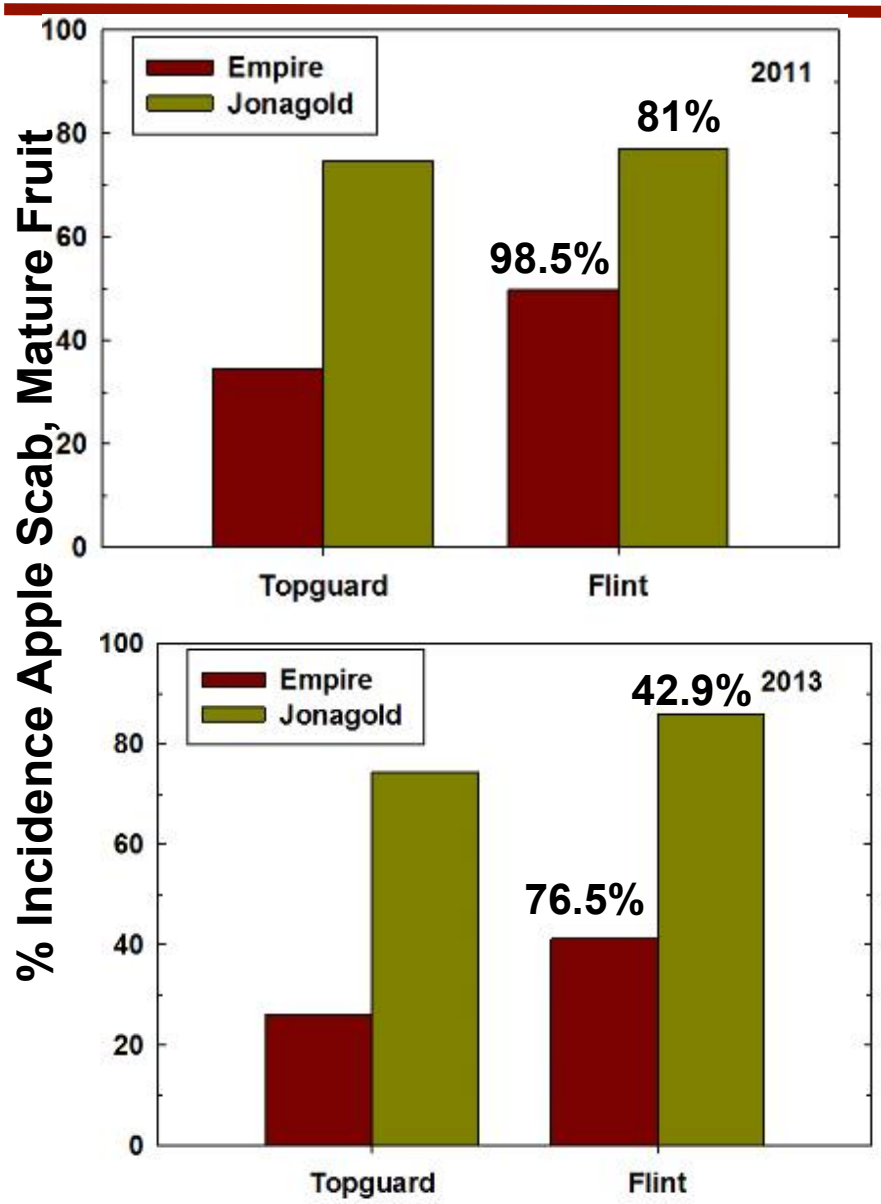


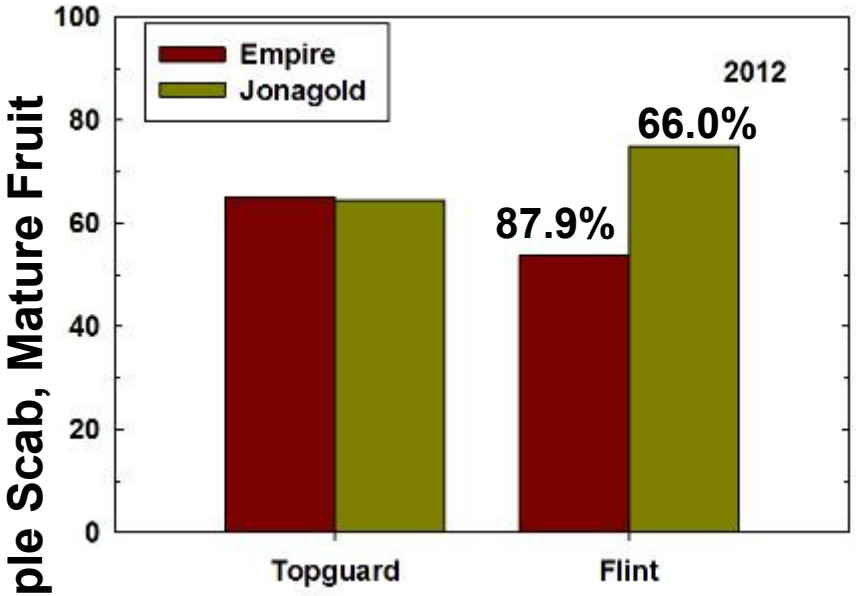
Cultivar + practical resistance?

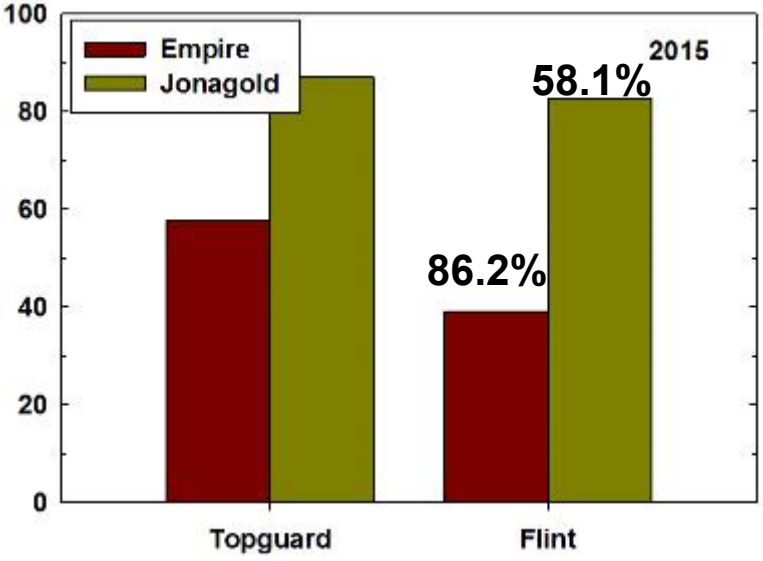


- 'McIntc *qualis* popula
- Populations test same in the lab (in vitro), however, less incidence of apple scab on 'Cortland'

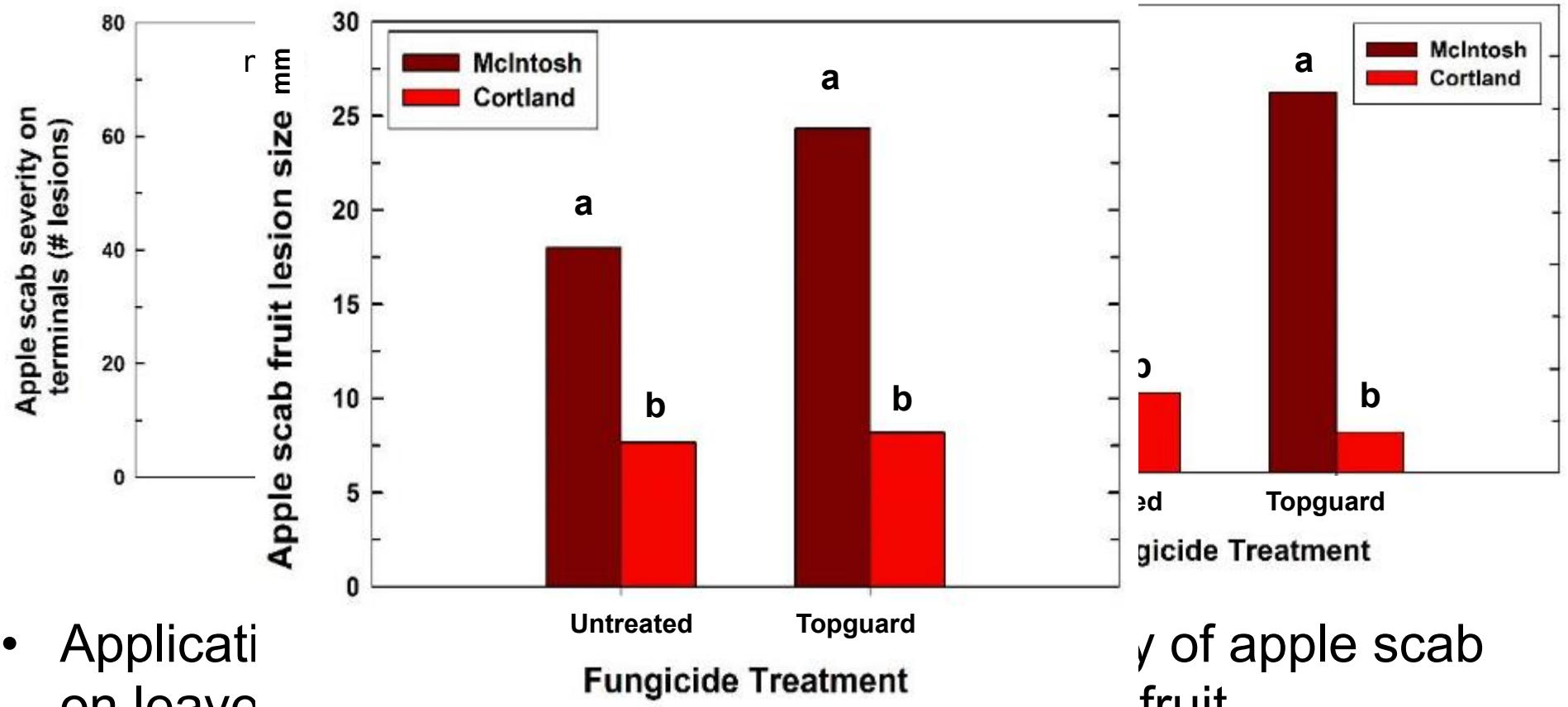
Cultivar Contribution towards Practical Resistance





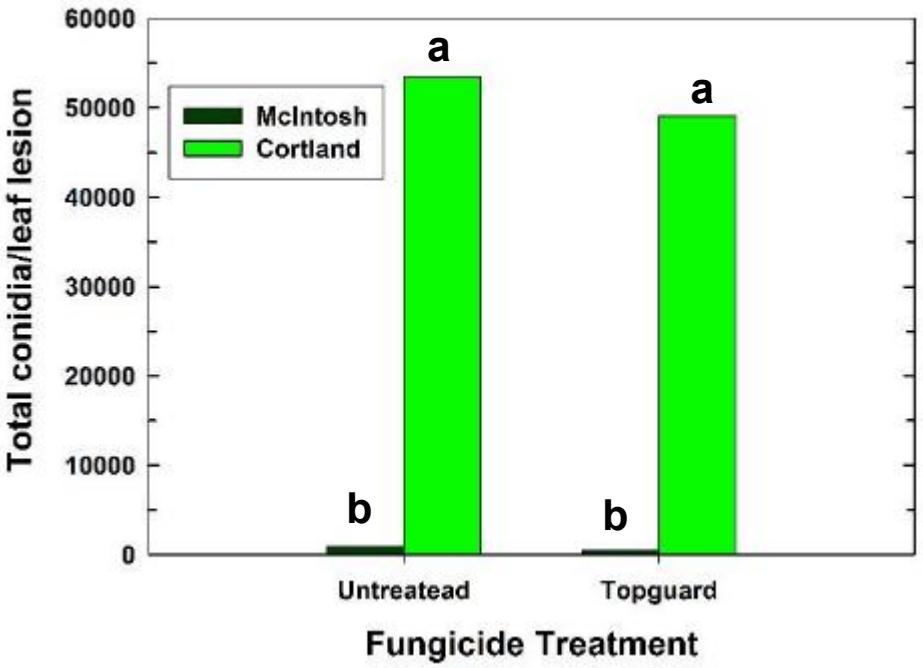


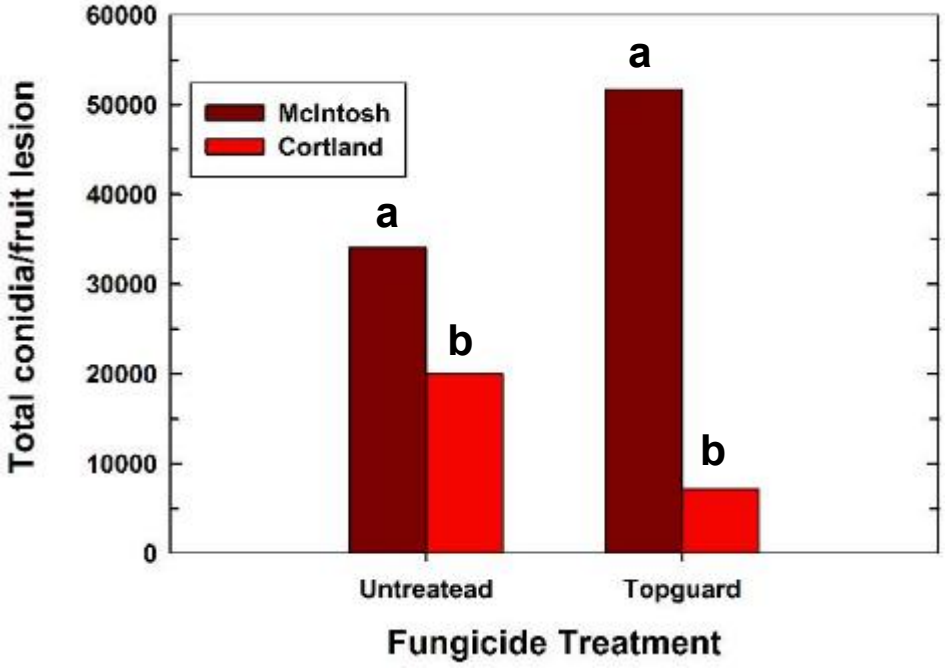
Cultivar Contribution towards Practical Resistance



- Applicati y of apple scab on leaves for both cultivars but only 'Cortland' fruit
- No significant difference in severity of apple scab on leaves, however scab severity much greater on more susceptible 'McIntosh' fruit

Cultivar Contribution towards Practical Resistance





- 'McIntosh' fruit have significantly more conidia per lesion than 'Cortland' fruit
  - High conidial production on leaves (Cortland) did not necessarily translate to greater production on fruit
- On 'McIntosh' fruit, Topguard applications stimulate conidial production

DMI Fungicide Practical Resistance: Cultivar Contribution Summary

- 2011-2015: Practical resistance to Flint apparent on ‘Empire’ but not ‘Jonagold’
  - Trend with Topguard breaks down in 2012 and 2014 Conidial production on fruit apple scab lesions was greater on cultivars with ‘McIntosh’ parents
- Application of fungicides to which *V. inaequalis* may have resistance (*in vitro* or molecular confirmation) but may still provide satisfactory control against apple scab on less susceptible cultivars
  - Weather? Overwintering inoculum? Fungicide/host interaction?
- Ineffective fungicides due to resistance may still provide scab control on some cultivars

Apple Scab Management Challenges

How do we manage apple scab when it's resistant to everything?

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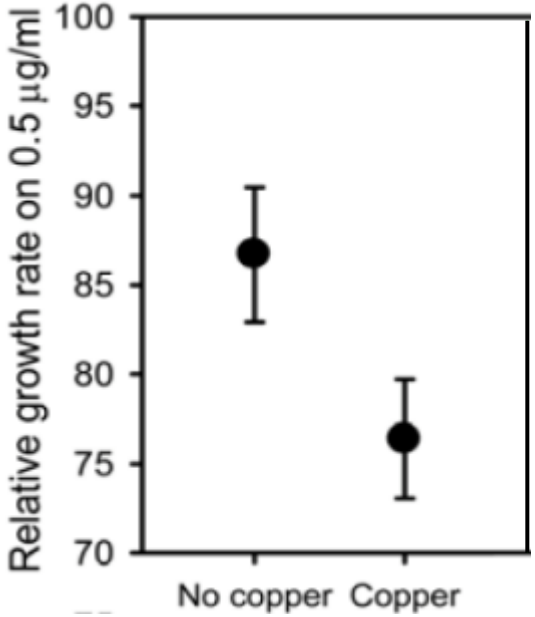
DMI Practical Resistance: Delayed Dormant Copper

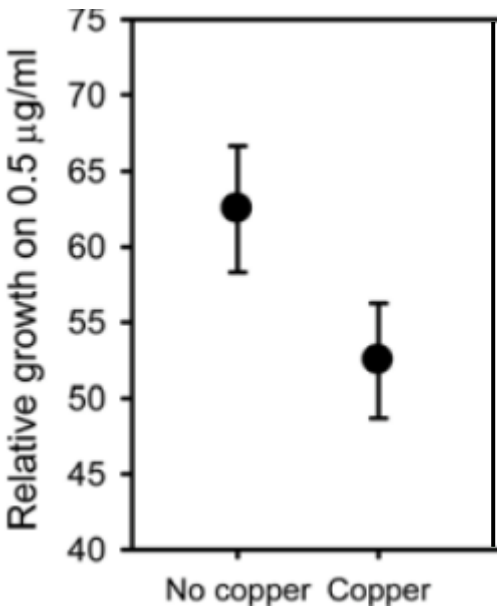
- Traditional inoculum reduction methods:
  - Burn, blow, remove: 62 to 84% reduction
  - Leaf Shredding: 40 to 95% inoculum reduction
  - Urea (40 lb/A), foil lining floor, biologicals? lime sulfur?

DMI Practical Resistance: Delayed Dormant Copper

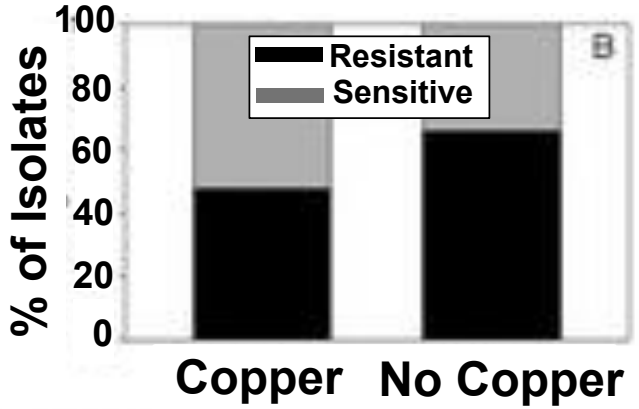
- Pfeufer and Ngugi, 2012: Grower survey
- Evaluated myclobutanil and fenbuconazole sensitivity of 644 isolates of *V. inaequalis* collected from 20 PA orchards in 2008/9



Myclobutanil

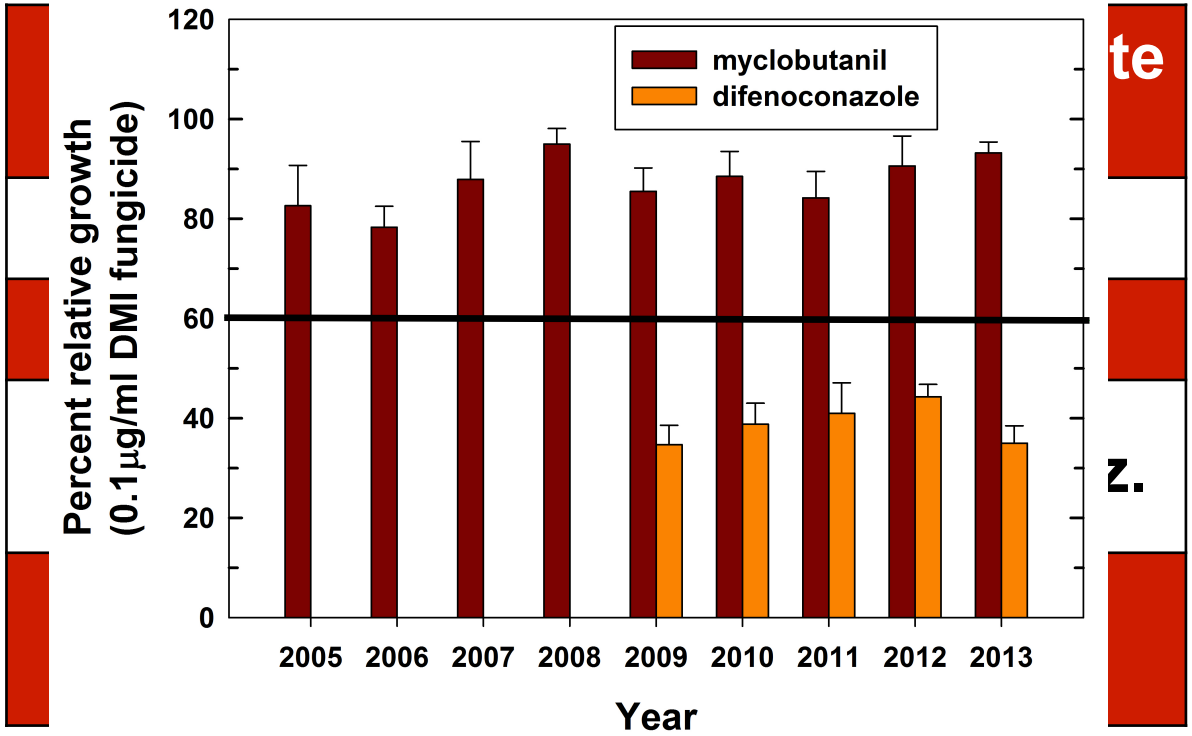


Fenbuconazole



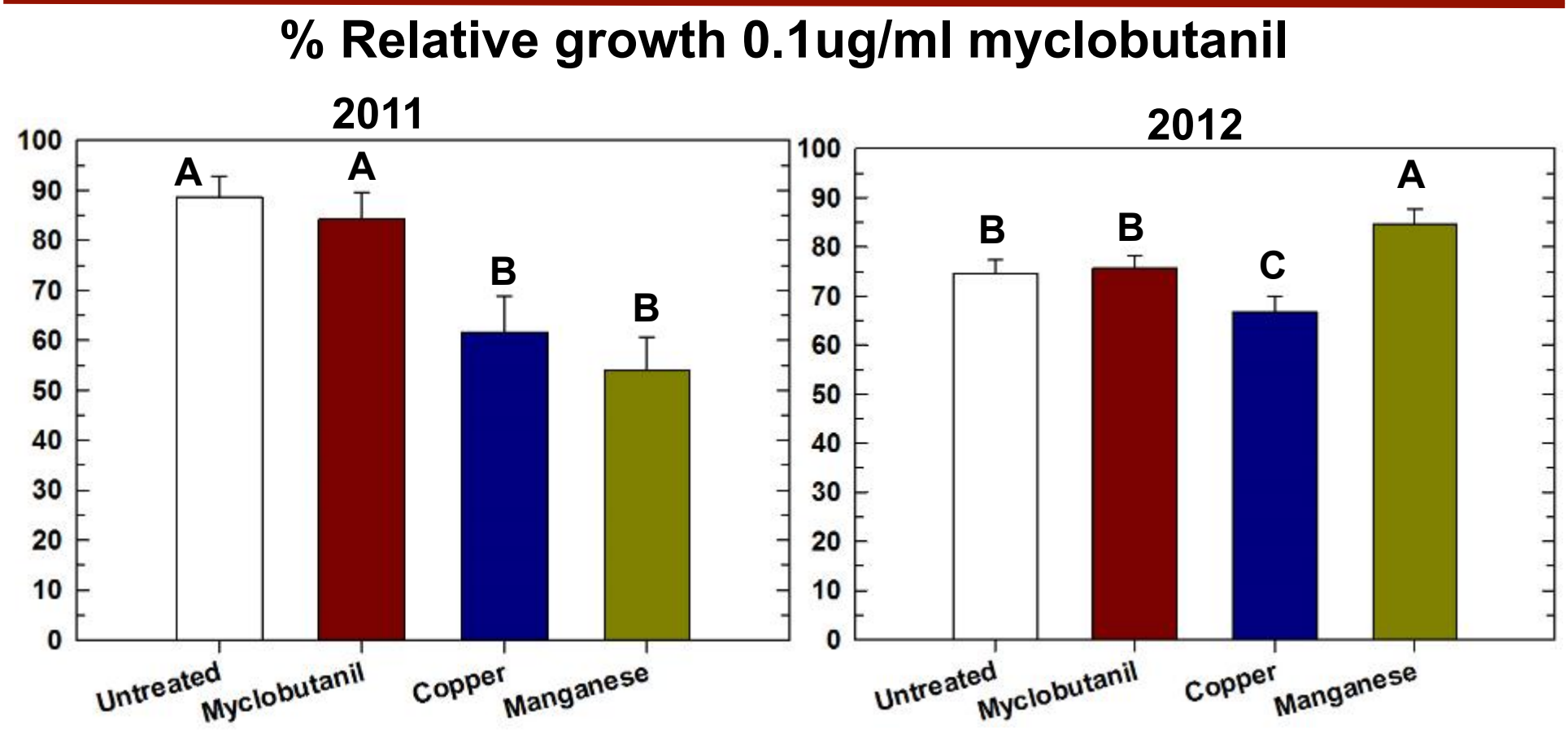
Dormant copper application⟶ Increased DMI sensitivity

Delayed Dormant Applications: 2011-2012



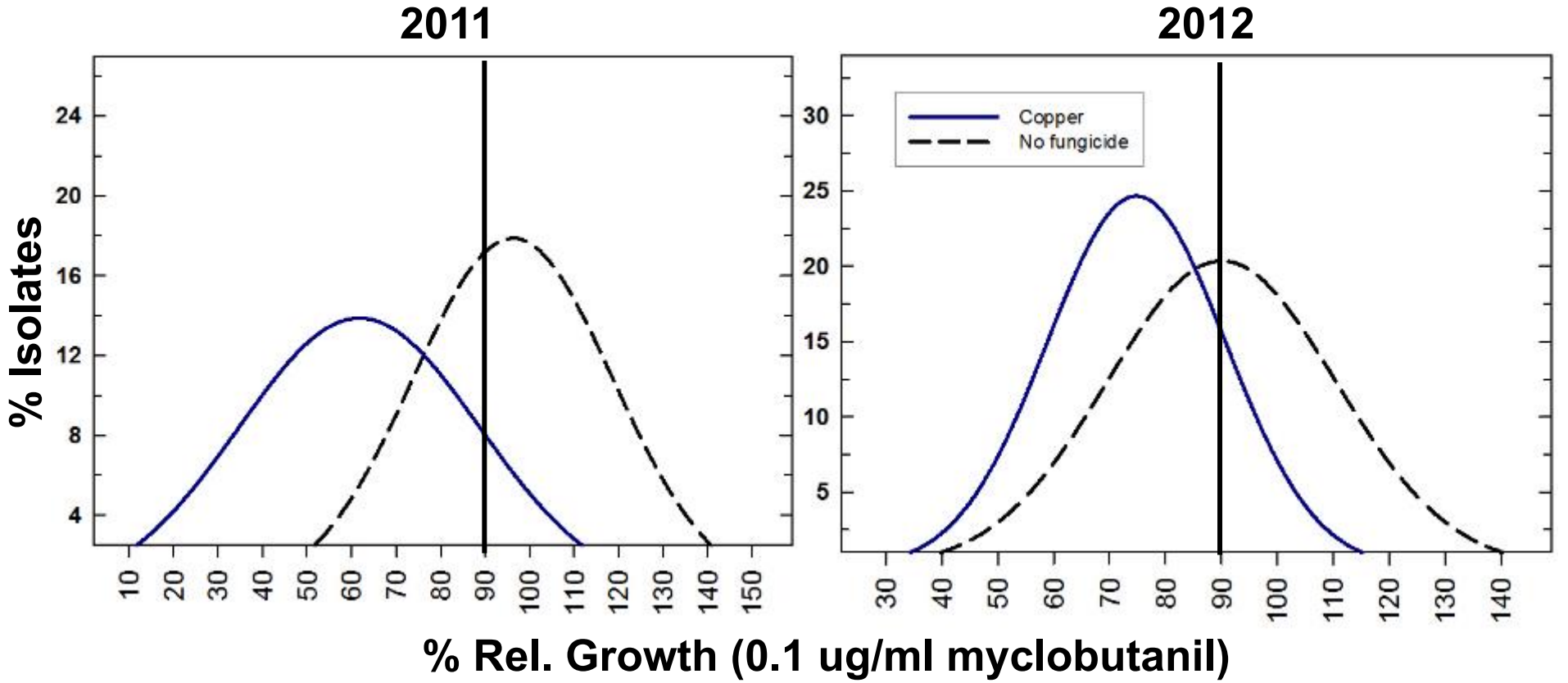
- Applications applied to ‘McIntosh’ at silver tip
- Green tip to 2C: Captan 80WDG (2.5 lb) + Penncozeb 75DF (3 lb)
- *V. inaequalis* population: stable resistance to myclobutanil

Delayed Dormant Applications: Myclobutanil Sensitivity



- *V. inaequalis* isolates exposed to delayed dormant copper applications: Significantly more sensitive to myclobutanil in 2011 and 2012

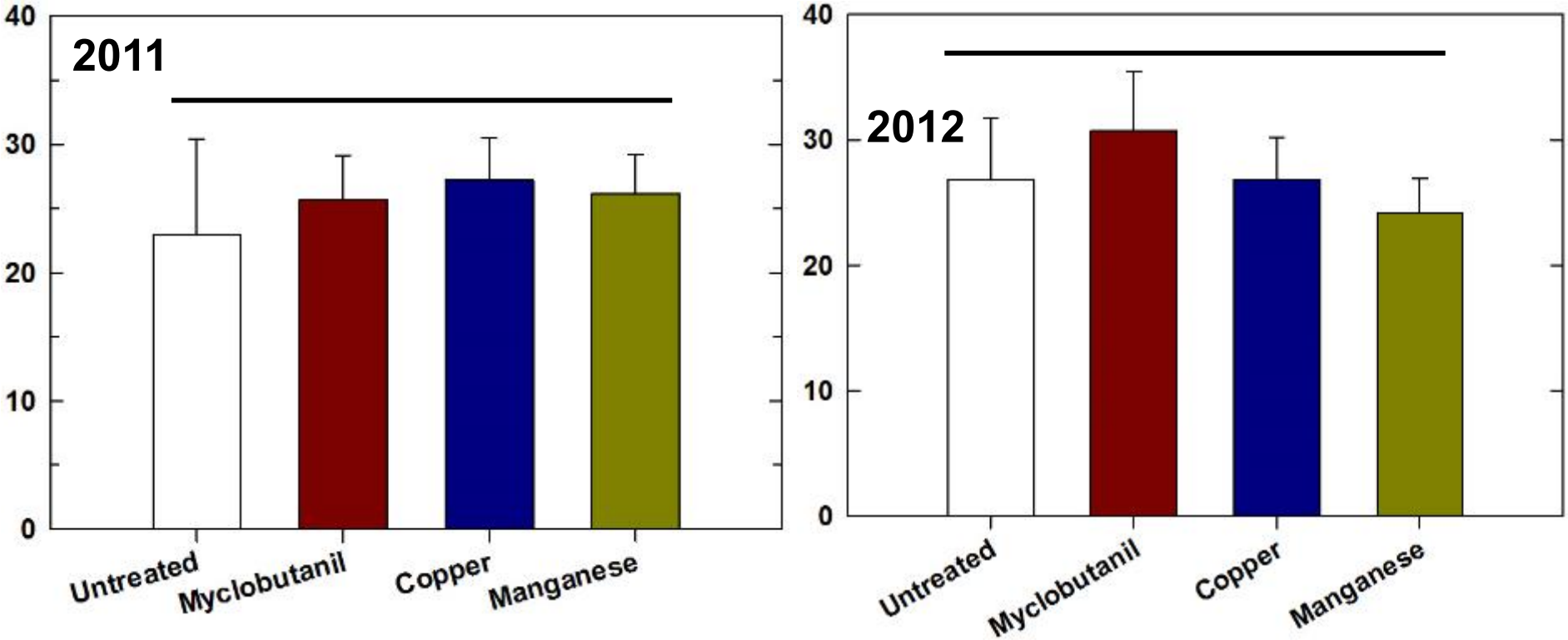
Delayed Dormant Applications: Myclobutanil Sensitivity



- Significantly greater number of isolates with high levels of resistance (≥90 %RG) to myclobutanil for non-treated program
- Isolates with high levels of resistance (>90 %RG) most impacted by d.d. copper treatment

Delayed Dormant Applications: Dodine (Syllit) Sensitivity

- Sensitivity of *V. inaequalis* isolates to dodine collected from population sensitive to dodine



- No significant effect of delayed-dormant treatment on sensitivity to dodine
- Effect of d.d. copper may only apparent with practical resistance

Delayed Dormant Copper: Take Home Messages

- Copper: Consistently increased sensitivity to myclobutanil
  - Cellular processes devoted in myclobutanil-resistance to also deal with copper influx?
  - Application for resistance management purposes or delaying onset of practical resistance?
- Myclobutanil: Did not affect DMI sensitivity
  - Most likely would decrease myclobutanil sensisitivity in populations without such high levels of practical resistance
- Manganese: Inconsistent results
  - Effect of formulation (2012: rain and leaf wetness following application)

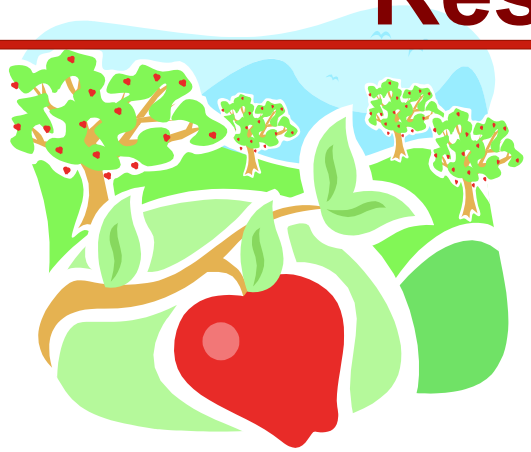
What about summer applications?

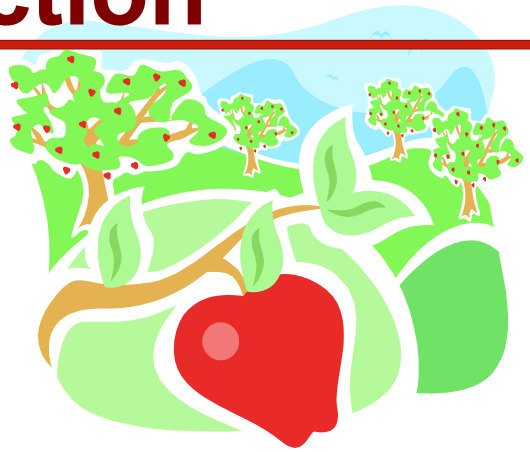
- Nearly all of new chemistries in premix fungicides effective / marketed for summer diseases
  - Inspire Super (difenoconazole + cyprodinil), Luna Sensation (trifloxystrobin + fluopyram), & Merivon (pyraclostrobin + fluxapyroxad), Aprovia (benzovindiflupyr)
  - Cover spray programs: 3rd cover to harvest: flyspeck/sooty blotch, late mildew, & fruit rots

Fungicide Application Timing and Resistance Selection

- Does application timing influence selection for resistance in *V. inaequalis* populations in the following season?
  - Will applications of difenoconazole for summer diseases select for more resistant members within a population of *V. inaequalis*?

Fungicide Application Timing and Resistance Selection





Pink-2C | 3C-6C | Harvest | Winter | Green Tip | Pink

2010

Early Fungicide Program

Full Season Fungicide Program

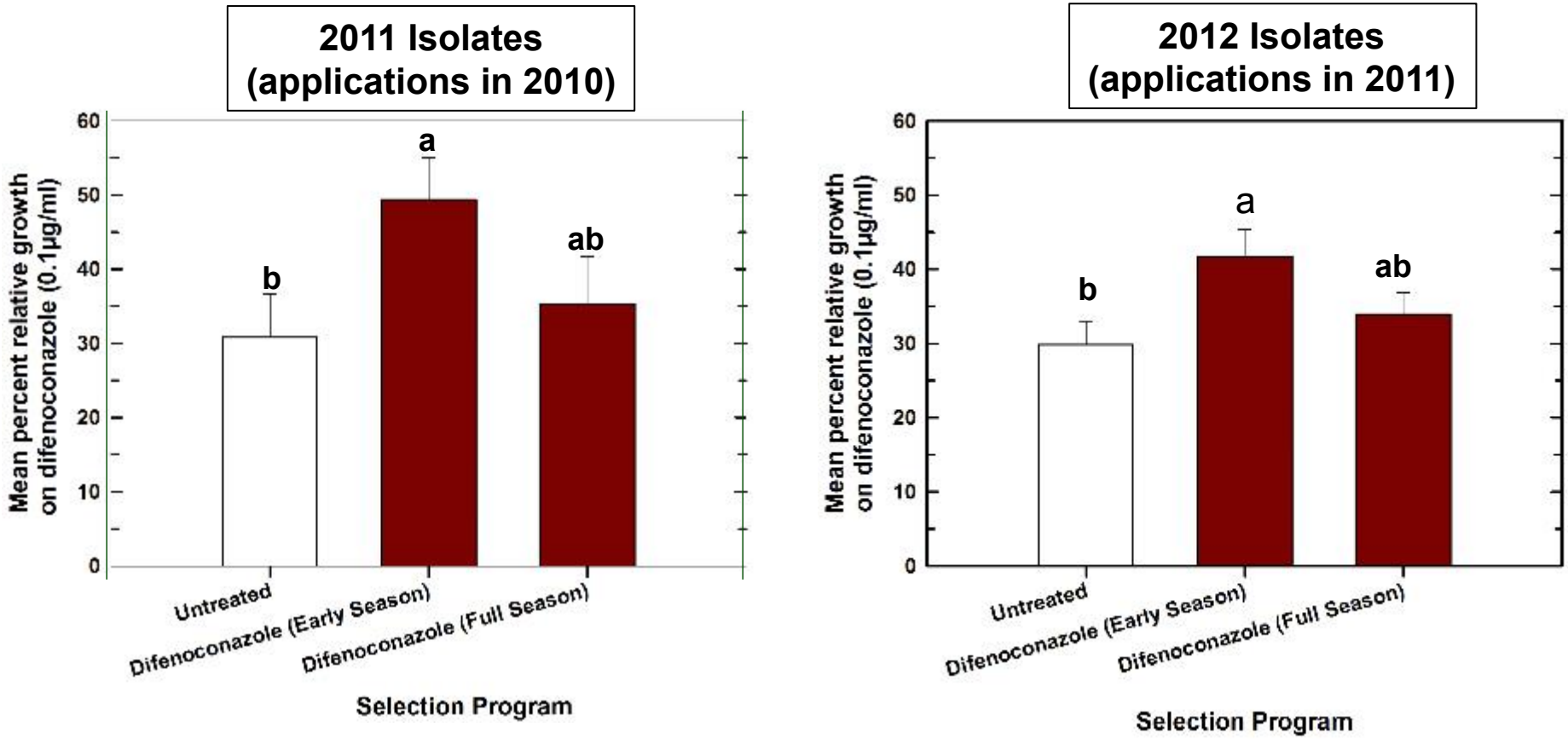
2011

Maintenance Program(captan + mancozeb)

Repeat through 2014

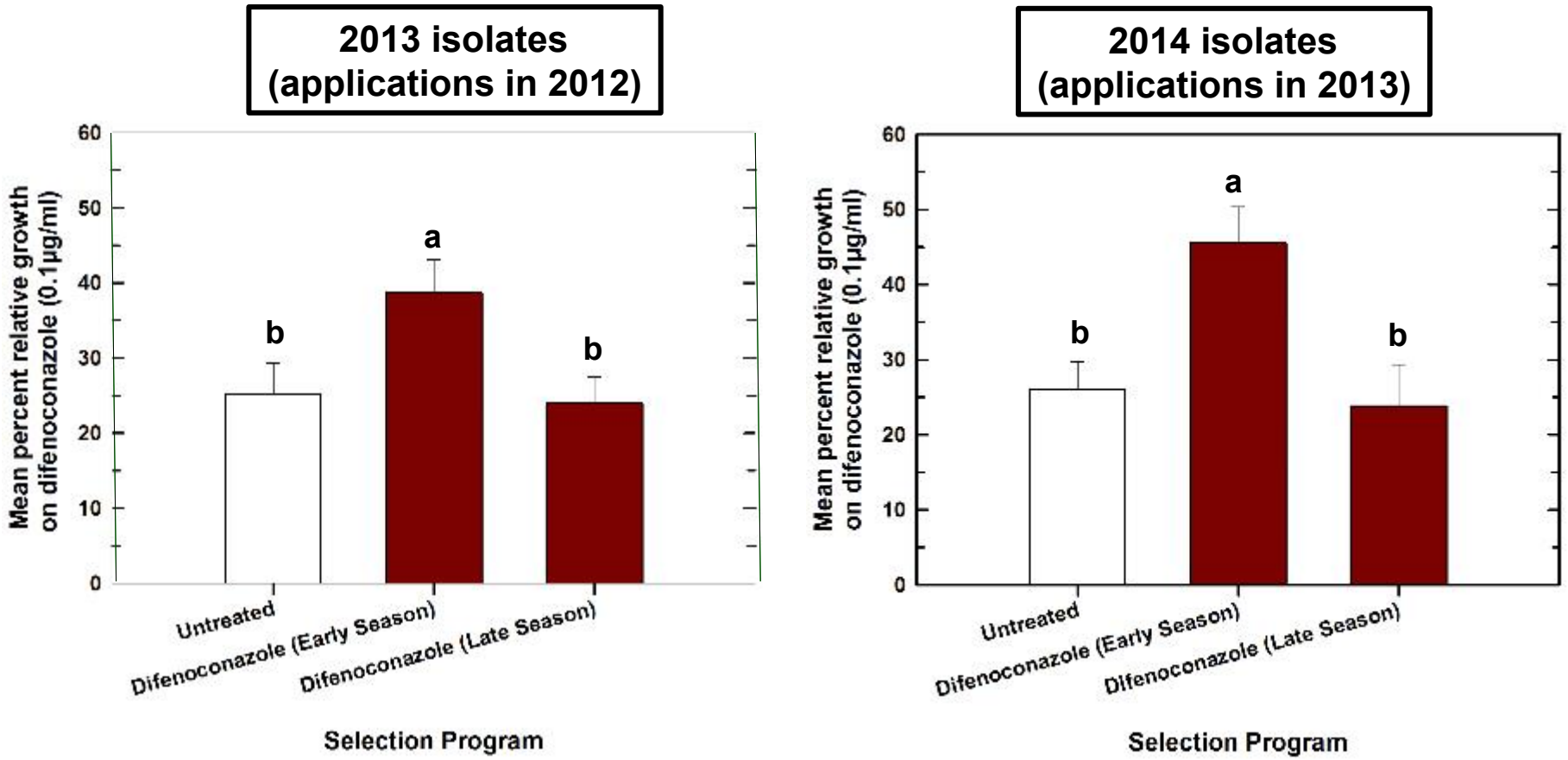
Evaluate treatment block populations (Primary apple scab lesions)

Difenoconazole Timing and Selection



- "Early season" (pink to 2nd): *V. inaequalis* isolates w/higher mean RG (**Higher Resistance**) than isolates from untreated trees, but not "full season" (pink to 6th cover) trees.

Difenoconazole Timing and Selection



- "Early season" (pink to 2nd): *V. inaequalis* isolates w/ higher mean RG (**Higher Resistance**) than isolates from UT & "late season" (3rd to 6th cover) trees

Application Timing Take Home

- Summer cover applications of difenoconazole do not select for difenoconazole resistance more than “Early season” programs
  - Late season: Fewer isolates with high levels resistance
- Does carry over inoculum play a role?
  - Late season programs reduce overall inoculum better than captan: fewer “resistant” members surviving over the winter?

Acknowledgements and Questions?

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